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Putting Environmental Infographics Center Stage: The Role of Visuals at the Elaboration Likelihood Model's Critical Point of Persuasion

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Abstract

Infographics, which integrate visuals and text, can increase audience engagement with message content. Relying on two experiments, this study demonstrates the role of visuals for decisions to critically evaluate pro-environmental messages. Using the Elaboration Likelihood Model as a theoretical foundation, we demonstrate that individuals engage in greater levels of issue-relevant thinking when shown infographics compared to messages that rely just on text or just on illustration, with learning preferences and visual literacy as moderators. The findings demonstrate that visual content is an important factor for persuasive message processing, and infographic messages hold opportunities for the communication of environmental issues.

Keywords

infographics, visual communication, elaboration likelihood model, pro-environmental behaviors

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Introduction

Infographics and other forms of data visualization are an increasingly popular means of conveying information (Fogel, 2013; Segel & Heer, 2010). Infographics—short for informational graphics—are defined as graphic representations of information (Lankow, Ritchie, & Crooks, 2012). Infographics function as more than artistic expression; they are visual displays designed to communicate information that range from anything as simple as a pleasing arrangement of figures to stylized illustrations to complex interactive data animations (Lester, 2011). Recently, newspapers' and newscasts' reliance on infographics in the form of annotated charts, maps, comic strips, and interactive graphics has fueled a rise in narrative visualization, or storytelling in which the visual component itself plays a vital role in telling the story rather than simply assuming a supportive role or being secondary to the text in the story (Segel & Heer, 2010). While it is difficult to measure the total number of infographics circulating, it is possible to gauge their importance via popularity and searchability. Google Search ranks trends 0 to 100 based on how often a keyword is searched. In 2012, the keyword infographic scored 100, representing peak search volume (Visual.ly, 2013). The rise of social media, such as Facebook and Twitter, has fueled interest in infographics and visual formats that present information in easily understood, digestible bite-size bits that can be "liked," commented on, and forwarded to others (Mashable, 2013). A single infographic has the potential to reach 15 million people (Mashable, 2013), indicating there is considerable promise to be found in infographics for science and environmental communicators to convey their information quickly and effectively.

Although infographics are witnessing a surge in popularity (Byrne & Cook, 2013), they are technically not a modern invention (Lankow et al., 2012). Infographics date back at least to Cro-Magnon man charcoal illustrations and Native American carvings drawn 20,000 to 10,000 years ago and used as informational communication devices or teaching aids (Byrne & Cook, 2013; Cook, 2013; Ford, 1993; Lester, 2011). Infographics have continued as important devices for conveying complex scientific information, from Da Vinci's iconic illustration *Vitruvian Man* done in 1490 to the *New York Times'* recent mapping of the threat of animal extinction (Marsh, 2012; Mol, 2011; Schaffzin, 2013).

Visual information, in general, and infographics, in particular, are potent, effective means of conveying information (Trumbo, 1999, 2000). Bloomfield and Doolin (2013) showed how symbolic imagery employed by a New Zealand activist group was a key aspect in the social movement's efforts to limit genetically modified foods in that country. O'Neill and Nicholson-Cole

(2009) demonstrated how powerful imagery related to climate change can help attract individual attention to the issue. These studies notwithstanding, little is known about how visual depictions of science information are understood by audiences and how these image-heavy modes compare to text-based presentations of science information. Our study seeks to fill this gap and responds to Trumbo's call made more than a decade ago to turn "a critical eye toward the functions, purposes, and effects of visual representation in the sciences" (Trumbo, 1999, p. 422). Thus, this study tested the relative impact of varying visual messages versus text-based messages on audience elaboration, or extent of issue-relevant thinking, for the presented science information over the course of two experiments by drawing on the Elaboration Likelihood Model (ELM) to explore whether these different message formats lead to central or peripheral processing.

Pro-Environmental Communication

We focus our study within the specific domain of pro-environmental behaviors and the messages that seek to promote them. A great deal of money and effort is spent on media messages that attempt to change attitudes about pro-environmental behaviors, including those having to do with the acquisition, consumption, and disposition of consumer products. As a potential solution to climate change, environmentally responsible consumer behaviors are often highlighted as meaningful, practical ways that individuals can help resolve the environmental crisis (Corbett, 2005). For example, reducing energy consumption, choosing organic food, and sharing cars are touted as ways individuals can help reduce greenhouse gases and pollution (Nisbet & Scheufele, 2007; Ockwell, Whitmarsh, & O'Neill, 2009).

The market has responded with an explosion of green or environmentally friendly product offerings. In 2010, the number of "greener" products—those claiming to offer environmentally friendly benefits—jumped 73% compared to the previous year, which itself had seen a jump of 79% from 2008 (TerraChoice, 2011). Looking at the organic food industry, the global market has risen steadily and is estimated to be worth $22.75 billion in 2007, with almost half of that coming from the U.S. market (Hunt & Dorfman, 2009). However, motivating individuals to engage with climate change and adopt these kinds of environmentally friendly behaviors is challenging (Atkinson & Rosenthal, 2014; Shellenberger & Nordhaus, 2005). As Shaw (2010) argued, simply providing information about suitable lifestyle changes seems to be ineffectual. More than a decade ago, Oskamp (2000, p. 382) recognized that social scientists must play a vital role in identifying "behaviors, values, attitudes, beliefs, incentives, norms, or barriers to behavior change." We contend that visual communication about environmentally responsible behaviors offers salutary opportunities for change.

Notwithstanding advancements in information technology and a media landscape of ever-increasing channels and choices, rates of scientific literacy and environmental knowledge are low and have remained so for decades (Brossard & Lewenstein, 2010; Nisbet & Scheufele, 2009; Treise, Walsh-Childers, Weigold, & Friedman, 2003). This is despite the long-held assumption that by providing individuals with information about climate change—by overcoming a deficit of information—audiences would become more interested, more knowledgeable and more engaged with the issue (Brossard & Lewenstein, 2010; Maibach, Roser-Renouf, & Leiserowitz, 2008). This information deficit model has been criticized for failing to put environmental understanding in context, discounting lay forms of knowledge and expertise, and not accounting for the cyclical, often discursive nature of communication (Maibach et al., 2008; Myers, 2003; Pitrelli, Manzoli, & Montolli, 2006). In an effort to broaden the simplistic, magic-bullet process presumed by the deficit model, other factors have been proposed, particularly factors highlighting the interactive and conditional nature of message effects (Brossard & Lewenstein, 2010). We take Brossard and Lewenstein's (2010) arguments as the jumping off point for our study. In particular, we are concerned with understanding how the way a message is framed and the way it is received by audiences can influence the message's effectiveness.

We draw on the ELM as a theoretical lens through which to test the importance of visual message effects compared to nonvisual message effects. Across two studies, we test the comparative influence of visual and verbal message elements on audience elaboration for pro-environmental messages. We also explore the role of visual literacy and learning preferences (either visual or verbal).

Elaboration Likelihood Model

Individuals are exposed to an unprecedented number of mediated visual messages as display capabilities abound in this digital era (Avgerinou, 2009; Petty, Briñol, & Priester, 2009); however, persuasive message processing theories do not account for the visual content of these mediated messages. Understanding the role of visual content in message presentation is especially important as screen-based and graphics-heavy communication becomes increasingly prevalent. However, theoretical frameworks about message processing tend to focus on message content as text-based information. This only accounts for information that is processed one word at a time, ignoring the fact that mediated messages are perceived holistically; that is, all visual elements of a message—both imagery and text—are seen as one constructed unit on first impression or initial glance. Additional effort is then taken by the viewer to process individual components, whether these are specific design elements or words. Thus, visual content and visual processing are likely influential concepts on how one chooses to process messages.

Surprisingly, however, these processing influences are rarely tested empirically and visuals are assumed to play a heuristic or peripheral role in message processing. Widely used persuasion processing models, such as the ELM, do not take visual presentation, preferences, or processing abilities into account (Petty & Cacioppo, 1986). The ELM, a dual-process model, describes attitude change via persuasive information processing as a consequence of either high or low cognition (i.e., level of elaboration), via central and peripheral processing routes as determined by a critical stage of influence (Petty & Cacioppo, 1986). Elaboration is defined as the "extent to which a person thinks about issue-relevant arguments" in a message and functions as the key differentiating factor between the central and peripheral processing of message information (Petty & Cacioppo, 1986, p. 128).

Central processing involves effortful thinking, where an individual is critically evaluating a message against prior knowledge and experience (Petty & Cacioppo, 1986; Petty et al., 2009). Attitudes that follow from central processing are often more enduring and resistant to change as the individual has used considerable resources to reach this view (Petty et al., 2009). Conversely, peripheral processing is less effortful and does not involve careful consideration of messages, a pattern attributed to low motivation or ability to process the message (Petty & Cacioppo, 1986; Petty et al., 2009). Notably, while the peripheral route is no less powerful for attitude formation, these attitudes are less enduring and less likely to withstand counter-persuasion attempts (Petty et al., 2009).

Although elaboration is a continuum, the ELM posits there is a critical stage for influence for high elaboration via central processing or low elaboration via peripheral processing. This determination begins with exposure to the persuasive communication message. Initial impressions of the message are critical to sway an individual's attention and interest. The ELM defines the message or the persuasive communication itself by the text contained, and oftentimes, evaluations of argument/message quality only consider the text within the message. The visual information or the visual content of the message, however, is relegated to the role of a peripheral cue (Petty & Cacioppo, 1986). This conceptualization of persuasive messages has largely worked to divide considerations of the message content and visual characteristics of messages. However, with the proliferation of increasingly visual mass media messages (Avgerinou, 2009; Spalter & van Dam, 2009), this crude distinction between text and visual message content, as well as the lack of visual processing considerations, hinders the use of the ELM for evaluating message designs that persuade individuals to engage in pro-environmental behaviors.

Visual Communication Strategies

Visual communication is defined as intentional communication that relies on the visual presentation of images and textual information (Avgerinou & Pettersson, 2011; Debes, 1968). It has long been recognized that images overpower words for attitude formation and change, especially in persuasive political campaign messages (Griffin, 2008; Messaris, 1994). Images often "win out" with their message persuasiveness over text or speech (Griffin, 2008; Messaris, 1994) These effects also hold for specific design elements; for example, a simple font replacement can heighten the emotional and persuasive power of messages (Juni & Gross, 2008).

Visual messages, including those that incorporate text elements, are perceived holistically initially; it takes further inspection and effort to process the individual components, including words, one at a time (Dake, 2005). Thus, visual presentation influences the necessary first step in the communication process—gaining the viewer's attention and interest. Individuals constantly evaluate visual messages they encounter, deciphering not just the content but also the relationship, if any, between the visual, other objects, and themselves (Berger, 1972; Rose, 2007). There is a complex relationship between a message's visual design and the viewer's interpretation of meaning (Rose, 2007; Trumbo, 1999).

Visual representations have the power to communicate more efficiently, and often more effectively, than words alone (Trumbo, 1999). Images, illustrations, or other visual representations have the power to communicate an "immediate visceral understanding" beyond the abilities of text (Green & Myers, 2010; Reavy, 2003). Through the ability to elicit emotional cues and presentation of implicit association, comparisons, or correlations, visuals can convey affective and cognitive information at a glance (Barry, 1997; Messaris, 1997). Furthermore, when conveying abstract scientific concepts, visual references allow audiences to transcend the constraints of language for meaning interpretation (Trumbo, 1999, 2000). It is likely that the visual presentation—specifically the integration of text and visuals—of a message design influences decisions for elaboration. Accordingly, we expect greater elaboration when messages are presented in a visually integrative manner than via a text-based message:

Hypothesis 1: Individuals exposed to a pro-environmental infographic message will experience significantly greater elaboration than those exposed to pro-environmental text-based message, when the quantity of text is held constant.

Learning Preferences

Learning preferences for information presentation format may also influence one's willingness to engage in critical thought about pro-environmental messages. While there are many learning preference dimensions, one's preference for visual or verbal information is a key consideration for educational information and may consequently be influential for decisions to process persuasive messages where individuals learn about and apply information to uphold an attitude or engage in a pro-environmental behavior (Felder & Henriques, 1995; Felder & Silverman, 1988; Felder & Spurlin, 2005). Learning preferences are the culmination of innate qualities and learned strengths that influence individuals to prefer a particular message format. Specifically, visual learning preferences are inherent or developed personal factors that influence one to prefer visual information presentation formats to text (Felder & Silverman, 1988; Felder & Spurlin, 2005; Messaris, 1994). Individuals who possess modality strength or preference for processing visual information are more likely to be satisfied with, interpret, and remember graphic communication formats (Barbe & Milone, 1981; Felder & Silverman, 1988; Tait, Voepel-Lewis, Brennan-Martinez, McGonegal, & Levine, 2012). Conversely, other individuals prefer to receive text-based information. Although this is visual in nature, the process of interpreting written words often involves the conversion to spoken words internally and is processed as auditory information (Felder & Henriques, 1995). While this study does not directly address the influence of learning styles—which include expressed preferences and actual strengths—for educational effectiveness (Pashler, McDaniel, Rohrer, & Bjork, 2009), we aim to shed light on whether one's expressed learning preference has an influential role for the processing of varying persuasive messages formats. Therefore, we propose the following hypotheses regarding the influence of learning preferences for message elaboration:

Hypothesis 2a: Individuals with visual learning preferences will have significantly greater elaboration with a pro-environmental infographic message.

Hypothesis 2b: Individuals with verbal learning preferences will have significantly greater elaboration with a pro-environmental text-based message.

Visual Literacy

The conceptualization and use of visual literacy has a diverse history. Theorists and scholars have drawn on narrow interpretations applicable to their specific research, with the result that visual literacy remains only loosely defined (Avgerinou & Pettersson, 2011). Still, extant literature indicates a consensus that visual literacy incorporates enhanced abilities to interpret (i.e., "read") and create (i.e., "write) visual materials (Avgerinou & Pettersson, 2011; Brumberger, 2011; Messaris & Moriarty, 2005; Spalter & van Dam, 2009). This study uses research on visual literacy to guide the analysis of how individuals' abilities to make meaning of visual information, understand the intentions of the creator, and have an awareness of possible alternate meanings will affect their decisions about central or peripheral processing of messages that encourage pro-environmental behaviors. More specifically, this study uses the concept of visual literacy to determine the "degree of self-consciousness about [one's] role as interpreter" and to explore how the degree of one's perceived ability to appraise or "read" visual symbols and their associated culturally constructed meaning affects their ability and choice to critically evaluate persuasive messages (Messaris, 1994, p. 135).

Theorists concerned with the educational value of visual literacy would argue that higher levels of visual literacy give viewers the skills to identify and decode the symbolic meaning of visual information, which could potentially enable more thoughtful evaluation of a message (Avgerinou & Pettersson, 2011; Trumbo, 1999). On the other hand, communication scholars often focus on the ability of individuals with high visual literacy to critically consume visual information, which makes them less susceptible to visual persuasion tactics (Messaris, 1994; Messaris & Moriarty, 2005). In this light, visually literate audiences, as critical consumers, may actually be less likely than visually illiterate individuals to elaborate on persuasive messages where they detect strategies meant to conjure unconscious associations. Individuals with low visual literacy, or those less confident in their visual interpretation abilities, may be more likely to engage in elaborative processing for visual messages as they are drawn into the narrative storytelling of visual information. Given the lack of research as to which of these approaches is more influential when individuals are processing infographics or data visualizations, we ask the following research question:

> **Research Question 1:** Does an individual's perceived level of visual literacy influence the level of elaboration for pro-environmental text-based or infographic messages?

Experiment 1

A controlled experiment was used to investigate the influence of visual content, learning preferences, and visual literacy on elaboration with a 2 × 2 × 2 factorial design. The between-subjects design used a 2 (message format: text-based vs. infographic) by 2 (learning preferences: verbal vs. visual) by 2 (visual literacy: high vs. low) experimental design. For the first factor, participants were randomly assigned to conditions where they saw a text-based message or an infographic message. Learning preferences and visual literacy were measured factors.

Stimuli

Recycling was chosen as the topic for the experimental stimuli to ensure audience familiarity. Our goal in this study was not to test novelty or learning about an unknown topic but rather to evaluate the role of elaboration across visual and text-based conditions. According to Oskamp et al. (1991), Americans have been involved in recycling efforts for more than two decades, and they report that as early as 1991, approximately two thirds of all U.S. households were actively involved in curbside recycling or similar programs. The persuasive message in this study was formatted to look like a website page with the background, header, and browser bar consistent in both conditions (see Figure 1). Two conditions were created: a text-only message for the text-based condition and an infographic. The text-based condition displayed text in paragraph form against the background. This same text was placed in a design with complementary visuals for the infographic condition. Stimuli for both conditions were presented as embedded images in the online questionnaire.

Participants

Participants (n = 168) were recruited using Amazon's Mechanical Turk (MTurk), a crowd sourcing system that allows for a heterogeneous sample (Ross, Irani, Silberman, Zaldivar, & Tomlinson, 2010). Participants were compensated 25 cents for their time, a rate of pay consistent with the MTurk model and studies of best practices (Mason & Suri, 2012; Sun, Wang, & Peng, 2011). Previous research has underscored the reliability of MTurk as a source of study participants (Buhrmester, Kwang, & Gosling, 2011). Compared to samples of college students or Internet-based panels, MTurk participants are more demographically diverse, particularly in terms of socioeconomic status and ethnicity, yet study

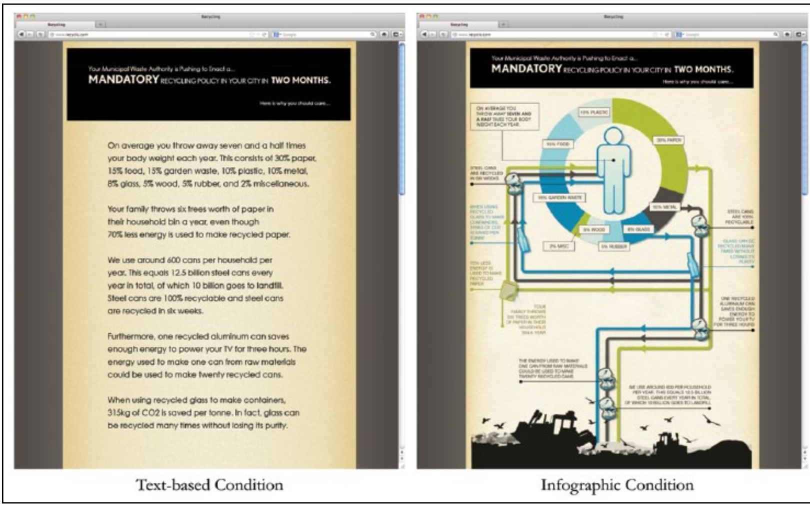

Figure 1. Experiment 1 stimuli.

results do not differ significantly across these different samples (Casler, Bickel, & Hackett, 2013; Leroy, Kauchak, & Mouradi, 2013; Yu, Willis, Sun, & Wang, 2012). For example, Burhmester, Kwang, and Gosling (2011) showed that MTurk data meet acceptable psychometric standards, with measures of extraversion, self-esteem, and social dominance among the MTurk sample being as reliable if not more so than those among non-MTurk samples.

Participants ranged in age from 18 to 64 years old (M = 33.79, SD = 12.73). The majority of participants (60%) were female. More than two thirds of the sample (69%) classified themselves as White and the remainder identified as Black or African American (11%), Asian or Pacific Islander (9%), biracial or multiracial (7%), or Hispanic (4%). Most participants had a bachelor degree (35%), associate degree (15%), or some college credit (30%). No significant demographic differences existed between the two experimental conditions.

Procedure

Once consent was given, participants were asked questions about their perceived level of visual literacy and learning preferences. Then, participants were randomly assigned to view the text-based or infographic recycling message.

Elaboration was measured after message exposure. Last, demographic information was collected. To measure the independent variables of learning preferences and visual literacy, along with the dependent variable of elaboration, the following measures were used.

Independent Variables

Learning Preferences. Learning preferences were measured through 11 dichotomous items designed to capture visual versus verbal learning preferences from the Index of Learning Styles© (Felder & Spurlin, 2005). Although there are a number of other approaches to understanding learning preferences, including the Myers-Briggs Type Indicator, Kolb's Learning Style Model, and the Herrmann Brain Dominance Instrument (Felder, 1996; Thomas, Ratcliffe, Woodbury, & Jarman, 2002), the approach used by Felder and colleagues is one of the few to make explicit distinctions between visual and verbal learning preferences on a single dimension.

All items included options that indicated whether individuals preferred to get new information, thought about information, or tended to remember information in either a visual or verbal format. For example, individuals selected whether they remember best "what I see" or "what I hear." Verbal responses and visual responses were summed independently, and the total of verbal responses was subtracted from the total of visual responses, meaning answers could range from −11 to 11 (M = 4.00, SD = 5.44; $KR\text{-}20$ = .76). Participants with a negative learning preference score were classified as verbal learning and those with a positive learning preference score were classified as visual learners.

Visual Literacy. Ten Likert-type items (M = 5.04, SD = 0.78, α = .86) were developed based on extant literature (Avgerinou, 2007; Messaris, 1994) to measure level of visual literacy through perceived abilities to interpret meaning from visual information. Participants reported their level of agreement from *strongly disagree* (1) to *strongly agree* (7) with statements such as, "When I look at photographs in advertisements or informational messages, it is easy for me to identify the purpose of the image" or "When I look at any visual in advertisements or informational messages, I can easily tell if the visual have multiple meanings." Responses from each participant were averaged and a mean split was used to separate individuals with high visual literacy and individuals with low visual literacy in the analysis.

Dependent Variable

Elaboration. Ten 7-point semantic differential items ($M = 4.97$, $SD = 1.01$, $\alpha = .84$) were used to measure elaboration. These items captured message elaboration through responses about the volume of thoughts the viewer has in reaction to the message, the vividness of these thoughts, and sensitivity to the message (Gkiouzepas & Hogg, 2011; Keys, Morant, & Stroman, 2009; McQuarrie & Mick, 1999; Unnava & Burnkrant, 1991). Example anchors for items included, "I had few thoughts in response/I had many thoughts in response," "does not provoke imagery/provokes imagery," and "no thought needed to evaluate/put thought into evaluating."

Results

Manipulation Check. To ensure that the stimuli were perceived as text only or as an infographic, participants were asked to rate their opinion of the message on a semantic differential scale that was anchored by "text-based" (1) and "visual-based" (7). As expected, the recycling infographic ($M = 5.08$, $SD = 1.47$) was perceived to be significantly, $t(166) = -11.939$, $p < .01$, more visual than the text-only condition ($M = 2.18$, $SD = 1.68$).

Findings. A 2 (message format) × 2 (learning preference) × 2 (visual literacy) ANOVA and Bonferroni adjusted post hoc comparisons were used to analyze all hypotheses and research questions that looked at effects of elaboration. ANOVA results are displayed with means and standard deviations for all experimental groups in Table 1. Hypothesis 1 predicted significantly greater levels of elaboration for individuals who saw the infographic compared to individuals who were exposed to the text-based message. This hypothesis was supported. There was a significant main effect of message format where individuals exposed to the infographic ($M = 5.28$, $SD = 0.83$) reported significantly greater ($p < .001$) elaboration than individuals exposed to the text-based message ($M = 4.66$, $SD = 1.09$).

Hypothesis 2a predicted that visual learners would demonstrate greater elaboration when exposed to the infographic. This hypothesis was supported (see Figure 2). We found that visual learners had significantly greater ($p < .01$) elaboration when shown the infographic ($M = 5.36$, $SD = 0.79$) versus the text-based message ($M = 4.76$, $SD = 1.10$). Hypothesis 2b predicted that verbal learners would have greater elaboration for text-based message. While the results were significant, they were not in the expected direction; this hypothesis was not supported. Contrary to expectations, verbal learners also demonstrated a significantly greater ($p < .01$) elaboration for the infographic ($M = 5.08$, $SD = 0.92$) versus the text-only message ($M = 4.27$, $SD = 0.96$).

Table 1. ANOVA Results for Elaboration With Means and Standard Deviations for Experimental Groups.

	F value	η^2	Text-based message, *M* (*SD*)	Infographic message, *M* (*SD*)	Visual-based message, *M* (*SD*)
Study 1—Recycling message ($df = 1,158$)					
Elaboration (message format only)	16.39***	.09	4.66[a] (1.09)	5.28[a] (0.83)	n/a
Elaboration (format × learning preference)	0.53	.00			
Visual learners			4.76[a] (1.10)	5.36[a] (0.79)	n/a
Verbal learners			4.27[a] (0.96)	5.08 [a] (0.92)	n/a
Elaboration (format × visual literacy)	2.01	0.01			
Low visual literacy			4.46[a] (1.15)	5.41[a] (0.74)	n/a
High visual literacy			4.91 (0.96)	5.16 (0.90)	n/a
Study 2—Genetically modified organisms message ($df = 1,334$)					
Elaboration (message format only)	3.38*	0.02	4.88 (1.07)	5.08 (1.15)	4.81 (1.09)
Elaboration (format × learning preference)	3.55*	0.02			
Visual learners			4.97 (0.99)	4.94 (1.22)	4.88 (1.15)
Verbal learners			4.65[a] (1.22)	5.32[ab] (0.98)	4.67[b] (0.95)
Elaboration (format × visual literacy)	0.218	0.00			
Low visual literacy			4.76 (1.04)	4.93 (1.06)	4.60 (.87)
High visual literacy			4.97 (1.08)	5.23 (1.23)	5.07 (1.27)

Note. Means in the same row sharing the same letter superscript differ at $p < .05$.
Significance at $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Thus, data indicate that regardless of learning preference, individuals exposed to the infographic experienced significantly ($p < .01$) higher elaboration than those exposed to the text-based message.

Research Question 1 inquired whether an individual's perceived level of visual literacy would influence the level of elaboration after exposure to a text-based or infographic message (see Figure 2). Data indicate that individuals who identified as having low visual literacy reported significantly ($p < .01$) higher elaboration for the infographic ($M = 5.41$, SD = 0.74) when compared to the text-based message ($M = 4.46$, $SD = 1.15$). Individuals with high visual literacy also reported higher elaboration for the infographic than the text-based message, although the difference was not significant ($p > .05$). These results indicate that although all individuals had higher elaboration with the infographic message, the difference was greater for individuals with low visual literacy.

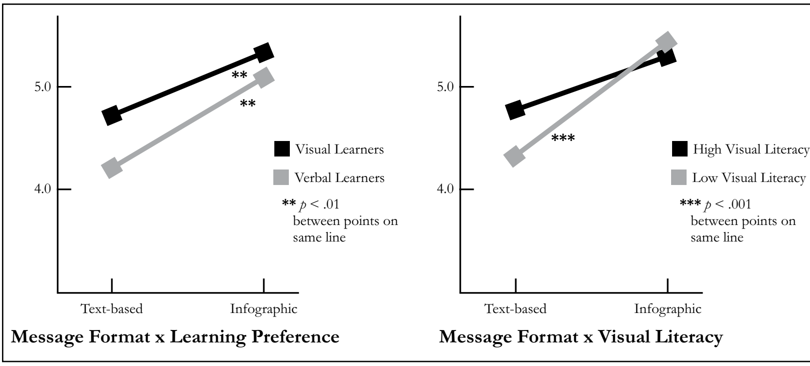

Figure 2. Experiment 1 results predicting elaboration.

Experiment 2

Experiment 1 demonstrated the importance of the visual message format as a centrally processed message element—individuals engaged in more effortful thought when the message content was shown in an infographic. While promising, an additional test is necessary to ensure the message effects were not simply attributable to a redundancy of information shown in both text and visual formats. In the first experiment, both the infographic and the text-based message contained the same textual information, but message concepts were also displayed visually (e.g., personal waste breakdown shown in a circular graph). As a result, the significant influence of our infographic stimuli on elaboration might be muddied by the fact it contains duplicate presentations of factual information. To isolate the influence of visual content as distinct from the volume of information, a second experiment was designed to control for the informational content and clarify the role of visual- versus text-based messages. To that end, a second experiment was carried out with a third condition added to the message format factor. In addition to the text-based and infographic stimuli, a third condition was added that relied almost exclusively on visual message elements, similar to the kind of message one might see in a photo or illustration. Varying the message design so that information is presented in either text or visual information, but not both, will provide further insight into individual's information presentation preferences and ability to elaborate. Therefore, we posit the following hypotheses and research questions to replicate and extend the findings from Experiment 1:

Hypothesis 3: Individuals exposed to a pro-environmental infographic message will experience significantly different levels of elaboration than individuals exposed to the pro-environmental text-based message or the pro-environmental visual-based message (i.e., photo illustration).
Research Question 2: Are there any significant differences for elaboration between the text-based and visual-based -message?
Hypothesis 4a: Individuals with visual learning preferences will demonstrate significantly greater elaboration with a pro-environmental infographic message.
Hypothesis 4b: Individuals with verbal learning preferences will demonstrate significantly greater elaboration with a pro-environmental infographic message.
Hypothesis 4c: Message format and learning preferences will interact so that individuals with verbal learning preferences will be more likely to elaborate on a pro-environmental infographic messages than visual learners.
Research Question 3: Does an individual's perceived level of visual literacy influence the level of elaboration for a text-based, visual-based, or infographic a pro-environmental message?

The objective of this second experiment was to determine if the way the information is presented—either through visual representations, text representations, or a combination—would influence decisions for elaboration. This experiment used a 3 (content format: text-based vs. infographic vs. visual-based) by 2 (learning preferences: verbal vs. visual) by 2 (visual literacy: high vs. low) between-subjects design. The first factor, content format, was represented by the mode of presentation for the message's information and differed from the stimuli in experiment

1 where the text was held constant and only the format was altered to a visually integrated design. As with the first experiment, the remaining two factors were measured.

Stimuli

To test the role of central processing of visual messages across a different context, this second study used GMO (genetically modified organisms) labeling as the message subject. By extending the findings to a different context, we are better able to validate the effects as more than isolated or singular (Thorson, Wicks, & Leshner, 2012). GMO labeling was chosen as the topic of the second study because it represents an environment-related issue that is gaining traction in terms of public policy implications and consumer

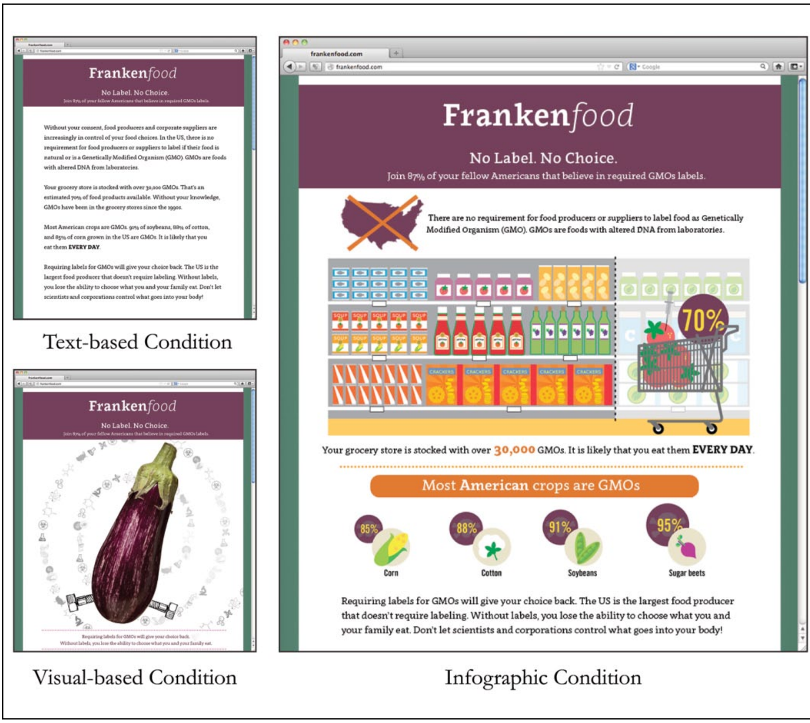

Figure 3. Experiment 2 stimuli.

awareness, but it remains an issue about which there is considerable confusion and ambiguity (McInerney, Bird, & Nucci, 2004; Nucci & Kubey, 2007).

Given our desire to systemically vary *how* the information is presented, the content was held as consistent as possible across conditions, albeit displayed in either text or visual format. To ensure that we were not simply testing the same message with additional visual information, the designs were created to have a balance of content shown in either text or graphic form (see Figure 3). The three conditions included a text-based message, an infographic message, and a visual-heavy message. The text-based condition had only the web browser shell, title bar, and text in standard paragraph form. An infographic using some of the text from the text-based condition and visual replacements for removed sections constituted the second condition. Last, only minimal text was retained for the visual-heavy condition, as this message relied predominantly on photos and illustrations to communicate the information.

Participants

Participants (n = 360) for Experiment 2 were also recruited through MTurk. Participants were 18 to 80 years old (M = 36.46, SD = 13.46). Gender was more evenly distributed between females (57%) and males (42%) in Experiment 2. The majority (77%) of respondents identified as White, with the reminder selecting Black or African American (8%), Asian or Pacific Islander (5%), Hispanic (3%), biracial or multiracial (3%), or other (3%). While level of education varied for participants, those that had a bachelor degree (34%), some college credit (31%), or high school diploma (12%) comprised the majority of the sample. There were no significant demographic differences found among experimental condition groups.

Procedure

The procedure was identical to Experiment 1 with the exception of adding an additional manipulation check item to distinguish perception of the illustrated (i.e., infographic) and photographic (i.e., visual-based) stimuli. Experiment 2 relied on the same variables from Experiment 1: learning preferences (M = 2.92, SD = 5.81, $KR\text{-}20$ = .78), visual literacy (M = 4.92, SD = 0.86, α = .76), and elaboration (M = 4.92, SD = 1.11, α = .87). See Experiment 1 for item descriptions.

Results

Manipulation Check. Two semantic differential items were used to ensure that the stimuli were perceived as text-based and visual-based and that there was a clear distinction between the infographic and visual-based condition's photo illustration. Participants were asked to rate their opinion of the message on items anchored by "text (1)/visual(7)" and "illustration(1)/photo(7)." Each item was analyzed with an ANOVA and Tukey's post hoc comparisons to detect significant differences. As predicted, the text only condition (M = 1.85, SD = 1.58) was perceived to be significantly more text-based, $F(2, 355) = 249.114$, $p < .001$, when compared to either the infographic (M = 5.43, SD = 1.49) or visual-based condition (M = 5.57, SD = 1.31). Furthermore, significant differences, $F(2, 355) = 22.05$, $p < .001$, were also observed between the other two conditions; the infographic was perceived as an illustration (M = 2.83, SD = 2.11) while the photo-based image was seen as a photo (M = 4.39, SD = 1.98), as desired.

Findings. A 3 (message format) × 2 (learning preference) × 2 (visual literacy) ANOVA and Bonferroni adjusted post hoc comparisons were used to analyze all hypotheses and research questions. ANOVA results are displayed with means and standard deviations for all experimental groups in Table 1, alongside Study 1 results. Hypothesis 3 stated that there would be significant differences in elaboration between the infographic and both the text-based and visual-based formats. This hypothesis was supported. There was a significant main effect ($p < .05$) of message format with individuals in the infographic condition ($M = 5.08$, $SD = 1.15$) reporting greater elaboration than participants in the text-based message ($M = 4.88$, $SD = 1.07$) or the visual-based message ($M = 4.81$, $SD = 1.09$) conditions. In response to Research Question 2, the findings revealed there were no significant differences ($p > .05$) in elaboration between individuals who saw the text-based message or the visual-based message.

Regarding Hypothesis 4a, results did not indicate a significant increase in elaboration for visual learners who saw the infographic, thus leaving this hypothesis unsupported. Indeed, there were no significant differences ($p > .05$) in elaboration for visual learners across any message format. Conversely, Hypothesis 4b was supported. Data indicate that verbal learners shown the infographic ($M = 5.32$, $SD = 0.98$) had a significantly greater ($p < .05$) elaboration when compared to those who saw the text-based ($M = 4.65$, $SD = 1.22$) or visual-based message ($M = 4.67$, $SD = 0.95$). It is notable that the data replicate the surprising results from Experiment 1, which lead to the redirecting of this hypothesis for Experiment 2. Additionally, the interaction predicted in Hypothesis 4c was significant ($p < .05$) between message format and learning preferences. While visual learners do not have significantly different ($p > .05$) levels of elaboration across all conditions, verbal learners do report differences for the infographic as shown above (see Figure 4).

Last, Research Question 3 addressed whether one's level of visual literacy influences elaboration likelihood for any of the message types shown. While individuals with low visual literacy who saw the infographic ($M = 4.93$, $SD = 1.06$) did report higher levels of elaboration than those who saw the text-based ($M = 4.76$, $SD = 1.04$) or visual-based message ($M = 4.60$, $SD = 0.87$), no significant ($p > .05$) differences were found. Additionally, reported levels of elaboration for individuals with high visual literacy mirrored the responses from individuals with low visual literacy where the highest level of elaboration was reported for the infographic ($M = 5.23$, $SD = 1.23$) followed by the text-based ($M = 4.97$, $SD = 1.08$) and visual-based message ($M = 5.07$, $SD = 1.27$), but without significant ($p > .05$) differences (see Figure 4).

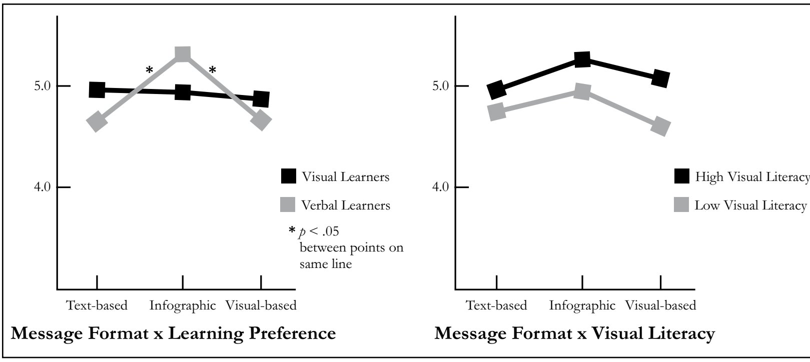

Figure 4. Experiment 2 results predicting elaboration.

Discussion

Visual design is an inherent and powerful element in science communication (Trumbo, 1999). In the process of translating scientific knowledge to persuasive communication targeting the public, science communication scholars and practitioners play a key role in understanding how words and images clarify science information and make it accessible for action (Trumbo, 1999). As levels of mediated message exposure continue to increase, it is critical that scholars and practitioners turn their attention to how visual representations of science influence audience responses and message effectiveness.

To test the role of visual information for pro-environmental behavior communication, this research systemically manipulated visual content and message format to evaluate its influence for persuasive message processing. Relying on two experiments, we assessed the influence of visual content, learning preferences, and visual literacy for elaboration. These findings advance our theoretical understanding of how visual representations of science invoke critical thinking in audiences, with implications for researchers and practitioners alike.

Experiment 1

Experiment 1 exposed individuals to messages encouraging recycling behavior with the same text presented in two formats—an infographic or traditional paragraphs—to determine if the message format would influence elaboration or extent of issue-relevant thinking. Our findings demonstrate that elaboration for the recycling message was greater when the same content was placed in an infographic. In other words, while holding the text constant, the visually integrated presentation of the message was shown to greatly influence decisions for a viewer to engage in issue-relevant thinking. This experiment demonstrates that visual representations, when integrated with text-based content, function as a tool for increased audience evaluation of message content, a critical step for persuasive science communication.

Further analysis also revealed that individual differences play a role in the decision to engage in central or peripheral message processing, albeit in directions unique to persuasive processing. Most notable was that learning preferences did not influence message processing in the direction the educational literature would suggest. Indeed, while visual learners did have an increase of elaboration with the infographics, it was individuals who identified themselves as verbal learners who demonstrated the greatest increase in elaboration for the visually integrated presentation format of the infographic compared to the standard paragraph text-based message. This finding was contradictory to our expectations and provides evidence that visual representations may function universally as communicative devices that are equally engaging for individuals across a variety of expressed learning or sensory preferences.

Additionally, when considerations of one's visual literacy were included the results indicated that increases in elaboration were more substantial for individuals who identified as having low visual literacy. These findings suggest that visual literacy may work in the opposite direction of other ability and motivation to process considerations, such as need for cognition (Epstein, Pacini, & Denes-Raj, 1996; Petty et al., 2009).

Experiment 2

Experiment 2 was conducted with GMO messages to further explore the role of visual information as nonredundant content in decisions to elaborate on the message content. This second experiment replicates the previous experiment, which demonstrated that infographics with visual depictions complementing text-based information lead to an increased elaboration likelihood, and extends it by using nonequivalent frames to further isolate the role of the visual information. All message information was shown as visual depictions or text, but not both. The findings indicate that audiences still engaged in the highest level of effortful thinking with the infographic, which presented some information as visuals and other as text. Indeed, that audiences respond with the highest level of engagement when visual and text-based content are integrated together in the infographic format, demonstrates that it is not necessarily the amount (or redundancy) of information shown, but the message format that is the greatest influence for central message processing. Interestingly, there were no reported differences in elaboration for the text-based message when compared to the visual-based message, indicating that audiences of these messages were similarly likely to attend to content presented in either of these two distinct ways.

In this experiment, we found that learning preferences have an influence on elaboration, where again, those individuals who classify themselves as verbal learners exhibited the strongest increase in elaboration when shown visuals integrated with text. While self-identified visual learners' level of elaboration was fairly consistent among message formats, verbal learners had greater elaboration when exposed to an infographic message. These results suggest that learning preferences are not always reliable indicators of actual behavior for persuasive message processing (Felder & Spurlin, 2005). While verbal learners may prefer text-based information, this preference does not override the communicative power of visual representations in the message design.

Message responses from individuals of all visual literacy levels indicate more elaboration for infographics, consistent with findings from Experiment 1. However, these findings reveal individuals with high visual literacy and those with low visual literacy reacted similarly to the different message formats. While in Experiment 1 individuals with low visual literacy experienced significantly greater elaboration with the infographic, the pattern was subtler in Experiment 2, where individuals of all levels of visual literacy experienced slightly greater elaboration with the infographic. While there was replication of a trend, the inconsistency of these findings calls for further investigation of when and how visual literacy functions as an influential personal factor at the critical point of persuasion for message engagement.

General Discussion

Taken together, these findings demonstrate that visuals matter. When environmental messages incorporate visual components in the form of infographics, they are more engaging than messages that rely just on text or just on illustration. The persuasive nature of these infographics holds true across different audiences, regardless of learning preferences or visual literacy. Individuals who report a preference for verbal learning styles as well as individuals who score lower on visual literacy scales actually elaborate more after exposure to infographic messages than they do with text-based messages. These patterns suggest the visual display style of infographic messages holds important opportunities for the communication of persuasive environmental issues.

Designing with infographics, while not a modern invention, has reached new levels of popularity as digital capabilities and consumer engagement with technology increase. Infographics represent an interesting lens through which to explore environmental communication issues. Our findings suggest that in addition to being popular, they are also very effective communication tools. This study demonstrated that visual information used to guide an audience through complex information is a reliable communication strategy to increase a viewer's willingness to critically evaluate pro-environmental information. Additionally, the inclusion of personal factors illustrates that while differences exist among visual preferences and processing abilities, there is a universal effect of increased thought given to message designs that integrate text and visual information.

In addition to the insight that visually formatted information yields greater elaboration than text-only formats, this study offers important theoretical implications for the ELM. Whereas traditionally ELM has viewed visual components of the message as secondary to text-based components, and as a result, more likely to facilitate heuristic or peripheral processing, this study indicates visual cues can and are processed as central elements of the message. Rather than being an afterthought in the dual-processing model, visuals ought to be considered more thoughtfully and fully in the elaboration process.

Inclusion of visual content—and personal variables for visual processing, such as visual literacy—will lead to a more comprehensive approach in persuasive communication research that will benefit scholars and practitioners alike in their efforts to effectively communicate messages for attitude and behavior change. By testing the additional visual processing concepts involved with the decision for elaboration and providing evidence for the role of visual processing preferences and abilities, this project furthers understanding of a viewer's willingness to critically evaluate message information and lead to potential implications for improved message engagement. Considering visual context and visual processing in the critical point of persuasion following message exposure allows persuasive communication research to examine unique visual factors that influence message processing. As digital capabilities abound, communication researchers and practitioners can no longer ignore the persuasive power of visual presentation to engage audiences, a critical first step for communication efforts for attitude and behavior change.

Further studies should build on this study's insights by testing visual cues in different contexts and exploring which moderators might influence the central processing of visuals. While the use of two pro-environmental topics demonstrated that the effects of visual information on elaboration hold consistent across different message types, a greater range of content should be tested to ensure these findings hold for a wider scope of pro-environmental messages. This study has already explored the moderating influence of learning preferences and visual literacy on the central processing of visuals. Additional moderators might be found in, for example, need for cognition and cognitive complexity. Last, as with all experiments, results from the cause-and-effect relationship tested here should be interpreted as a presence of effects and not as generalizable findings. Future replications of these findings are needed to determine the breadth of infographic effectiveness as a tool for engaging audiences.

Implication for Research and Practice

There are also important managerial implications for science and environmental communication professionals. These insights could help in message conception, development, and design, allowing scholars and practitioners to rethink the design of specific messages, as well as broader campaign development with greater emphasis on audience variables, such as information integration in a visual format. Interactive media host a plethora of opportunities for researchers and practitioners to cater to the visual desires of their audiences. As well, given infographics' apparent high viral quality, or the frequency and ease with which audiences pass along infographics on social media, it would benefit environmental communicators to design message campaigns with this in mind. Compared to traditional messages, infographics are more likely to be shared and forwarded (Mashable, 2013). Environmental communication campaigns could harness this energy by incorporating infographics as a central message feature. In a media environment where consumers are increasingly skeptical of messages and hard sell message claims are losing their effectiveness, infographics provide a visual method of engaging audiences with scientific information (Lankow et al., 2012).

The prevalence of visual messages today no longer allows us to ignore the role that visual content plays in decisions to process persuasive pro-environmental messages with effortful thinking. Science communicators should consider infographics and other forms of data visualization that encourage message engagement. In our increasingly screen-based communication formats, *how* information is presented may be as influential as *what* is presented for critically thinking about issue-relevant arguments. Additionally, personal factors—such as one's perceived ability to interpret visual information—may influence decisions to process environmental messages. In this study, individuals with lower visual literacy experienced greater elaboration with visual messages, which may be a key insight for consideration when designing messages with the intention that consumers will get involved with the persuasive story and allow the message's content to have a lasting impression on their pro-environmental consumption habits.

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References

Atkinson, L., & Rosenthal, S. (2014). Signaling the green sell: The influence of eco-label scource, argument specificity, and product involvement on trust. *Journal of Advertising*, *43*, 33-45.

Avgerinou, M. D. (2007). Towards a visual literacy index. *Journal of Visual Literacy*, *27*, 29-46.

Avgerinou, M. D. (2009). Re-viewing visual literacy in the "bain d'images" era. *Tech Trends*, *53*, 28-34.

Avgerinou, M. D., & Pettersson, R. (2011). Towards a cohesive theory of visual literacy. *Journal of Visual Literacy*, *30*, 1-19.

Barbe, W. B., & Milone, M. N. (1981). What we know about modality strengths. *Educational Leadership*, *38*, 378-380.

Barry, A. M. S. (1997). *Visual intelligence: Perception, image, and manipulation in visual communication*. Albany: State University of New York Press.

Berger, J. (1972). *Ways of seeing*. New York, NY: Penguin.

Bloomfield, B. P., & Doolin, B. (2013). Symbolic communication in public protest over genetic modification: Visual rhetoric, symbolic excess, and social mores. *Science Communication*, *35*, 502-527.

Brossard, D., & Lewenstein, B. V. (2010). A critical appraisal of models of public understanding of science using practice to inform theory. In L. Kahlor & P. Stout (Eds.), *Communicating science: New agendas in communication* (pp. 11-39). New York, NY: Routledge.

Brumberger, E. (2011). Visual literacy and the digital native: An examination of the millennial learner. *Journal of Visual Literacy*, *30*, 19-46.

Buhrmester, M., Kwang, T., & Gosling, S. D. (2011). Amazon's Mechanical Turk a new source of inexpensive, yet high-quality, data? *Perspectives on Psychological Science*, *6*, 3-5.

Byrne, D., & Cook, G. (2013). *The best American infographics 2013*. Boston, MA: Houghton Mifflin Harcourt.

Casler, K., Bickel, L., & Hackett, E. (2013). Separate but equal? A comparison of participants and data gathered via Amazon's MTurk, social media, and face-to-face behavioral testing. *Computers in Human Behavior*, *29*, 2156-2160.

Cook, G. (2013). Why Abraham Lincoln loved infographics. *The New Yorker*. Retrieved from http://www.newyorker.com/tech/elements/why-abraham-lincoln-loved-infographics

Corbett, J. B. (2005). Altruism, self-interest, and the reasonable person model of environmentally responsible behavior. *Science Communication*, *26*, 368-389. doi:10.1177/1075547005275425

Dake, D. (2005). Aesthetics theory. In K. Smith, S. Moriarty, G. Barbatsis & K. Kenney (Eds.), *Handbook of visual communication: Theory, methods, and media* (pp. 3-22). Mahwah, NJ: Lawrence Erlbaum.

Debes, J. L. (1968). Communication with visuals. *Et cetera*, *25*, 27-34.

Epstein, S., Pacini, R., & Denes-Raj, V. (1996). Individual differences in intuitive-experiential and analytical-rational thinking styles. *Journal of Personality and Social Psychology*, *71*, 390-405.

Felder, R. M. (1996). Matters of style. *ASEE Prism*, *6*(4),18-23.

Felder, R. M., & Henriques, E. R. (1995). Learning and teaching styles in foreign and second language education. *Foreign Language Annals*, *28*, 21-31.

Felder, R. M., & Silverman, L. K. (1988). Learning and teaching styles in engineering education. *Engineering Education*, *78*, 674-681.

Felder, R. M., & Spurlin, J. (2005). Applications, reliability and validity of the Index of Learning Styles. *International Journal of Engineering Education*, *21*, 103-112.

Fogel, B. (2013, October 18). Show, not tell: The rise of the infographic. *Science Friday*. Retrieved from http://www.sciencefriday.com/blogs/10/18/2013/show-not-tell-the-rise-of-the-infographic.html?series=20

Ford, B. J. (1993). *Images of science: A history of scientific illustrations*. New York, NY: Oxford University Press.

Gkiouzepas, L., & Hogg, M. K. (2011). Articulating a new framework for visual metaphors in advertising: A structural, conceptual, and pragmatic investigation. *Journal of Advertising*, *40*, 103-120.

Green, M. J., & Myers, K. R. (2010). Graphic medicine: Use of comics in medical education and patient care. *British Medical Journal*, *340*, 574-577.

Griffin, M. (2008). Visual competence and media literacy: Can one exist without the other? *Visual Studies*, *23*, 113-129.

Hunt, N., & Dorfman, B. (2009, January 28). How green is my wallet? Organic food growth slows. *Reuters*. Retrieved from http://www.reuters.com/article/2009/01/28/us-financial-food-organic-idUSTRE50R01C20090128

Juni, S., & Gross, J. S. (2008). Emotional and persuasive perception of fonts. *Perceptual and Motor Skills*, *106*, 35-42.

Keys, T. R., Morant, K. M., & Stroman, C. A. (2009). Black youth's personal involvement in the HIV/AIDS issue: Does the public service announcement still work? *Journal of Health Communication*, *14*, 189-202.

Lankow, J., Ritchie, J., & Crooks, R. (2012). *Infographics: The power of visual storytelling*. Hoboken, NJ: John Wiley.

Leroy, G., Kauchak, D., & Mouradi, O. (2013). A user-study measuring the effects of lexical simplification and coherence enhancement on perceived and actual text difficulty. *International Journal of Medical Informatics*, *82*, 717-730.

Lester, P. M. (2011). *Visual communication: Images with messages* (5th ed.). Independence, KY: Wadsworth, Cengage Learning.

Maibach, E. W., Roser-Renouf, C., & Leiserowitz, A. (2008). Communication and marketing as climate change–intervention assets a public health perspective. *American Journal of Preventive Medicine*, *35*, 488-500.

Marsh, B. (2012). Are we in the midst of a sixth mass extinction: A tally of life under threat. *The New York Times*. Retrieved from http://www.nytimes.com/interactive/2012/06/01/opinion/sunday/are-we-in-the-midst-of-a-sixth-mass-extinction.html

Mashable. (2013). *Rise of infographics: Marketing in the social-media age*. Retrieved from http://mashable.com/2013/01/26/infographics-marketing/

Mason, W., & Suri, S. (2012). Conducting behavioral research on Amazon's Mechanical Turk. *Behavior Research Methods*, *44*, 1-23.

McInerney, C., Bird, N., & Nucci, M. (2004). The flow of scientific knowledge from lab to the lay public the case of genetically modified food. *Science Communication*, *26*, 44-74.

McQuarrie, E. F., & Mick, D. G. (1999). Visual rhetoric in advertising: Text-interpretive, experimental, and reader-response analyses. *Journal of Consumer Research*, *26*, 37-54.

Messaris, P. (1994). *Visual "literacy": Image, mind, & reality*. Boulder, CO: Westview Press.

Messaris, P. (1997). *Visual persuasion: The role of images in advertising*. Thousand Oaks, CA: Sage.

Messaris, P., & Moriarty, S. (2005). Visual literacy theory. In K. Smith, S. Moriarty, G. Barbatsis & K. Kenney (Eds.), *Handbook of visual communication: Theory, method, and media* (pp. 481-502). Mahwah, NJ: Lawrence Erlbaum.

Mol, L. (2011). *The potential role for infographics in science communication* (Master thesis). Communication Specialization (9 ECTS), Biomedical Sciences, Vrije Universiteit Amsterdam.

Myers, G. (2003). Discourse studies of scientific popularization: Questioning the boundaries. *Discourse Studies*, *5*, 265-279. doi:10.1177/1461445603005002006

Nisbet, M. C., & Scheufele, D. A. (2007). The future of public engagement. *The Scientist*, *21*, 38-44.

Nisbet, M. C., & Scheufele, D. A. (2009). What's next for science communication? Promising directions and lingering distractions. *American Journal of Botany*, *96*, 1767-1778. doi:10.3732/ajb.0900041

Nucci, M., & Kubey, R. (2007). "We begin tonight with fruits and vegetables": Genetically modified food on the evening news 1980-2003. *Science Communication*, *29*, 147-176.

O'Neill, S., & Nicholson-Cole, S. (2009). "Fear won't do it": Promoting positive engagement with climate change through visual and iconic representations. *Science Communication*, *30*, 355-379. doi:10.1177/1075547008329201

Ockwell, D., Whitmarsh, L., & O'Neill, S. (2009). Reorienting climate change communication for effective mitigation forcing people to be green or fostering grass-roots engagement? *Science Communication*, *30*, 305-327. doi:10.1177/1075547008328969

Oskamp, S. (2000). Psychological contributions to achieving an ecologically sustainable future for humanity. *Journal of Social Issues*, *56*, 373-390.

Oskamp, S., Harrington, M. J., Edwards, T. C., Sherwood, D. L., Okuda, S. M., & Swanson, D. C. (1991). Factors influencing household recycling behavior. *Environment and Behavior*, *23*, 494-519.

Pashler, H., McDaniel, M., Rohrer, D., & Bjork, R. (2009). Learning styles: Concepts and evidence. *Psychological Science in the Public Interest*, *9*, 105-119.

Petty, R. E., Briñol, P., & Priester, J. R. (2009). Mass media attitude change: Implications of the elaboration likelihood model of persuasion. In B. Jennings & M. B. Oliver (Eds.), *Media effects: Advances in theory and research* (pp. 125-164). Hoboken, NJ: Routledge.

Petty, R. E., & Cacioppo, J. T. (1986). The elaboration likelihood model of persuasion. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 19, pp. 123-204). San Diego, CA: Academic Press.

Pitrelli, N., Manzoli, F., & Montolli, B. (2006). Science in advertising: Uses and consumptions in the Italian press. *Public Understanding of Science*, *15*, 207-220.

Reavy, M. (2003). Rules and the real world: An examination of information graphics in *Time* and *Newsweek*. *Visual Communication Quarterly*, *10*, 4-10.

Rose, G. (2007). *Visual methodologies: An introduction to the interpretation of visual materials*. Thousand Oaks, CA: Sage.

Ross, J., Irani, L., Silberman, M., Zaldivar, A., & Tomlinson, B. (2010, April). *Who are the crowdworkers? Shifting demographics in Amazon Mechanical Turk*. Paper presented at the ACM CHI Conference, Atlanta, GA.

Schaffzin, G. Y. (2013). Social movement information design and a curriculum of proper knowledge consumption. In A. Marcus (Ed.), *Design, user experience, and usability. Design philosophy, methods, and tools* (Lecture Notes in Computer Science, Vol. 8012, pp. 134-143). Berlin, Germany: Springer.

Segel, E., & Heer, J. (2010). Narrative visualization: Telling stories with data. *IEEE Transactions on Visualization and Computer Graphics*, *16*, 1139-1148.

Shaw, B. (2010). Using temporally oriented social science models and audience segmentation to influence environmental behaviors. In L. Kahlor & P. Stout (Eds.), *Communicating science: New agendas in communication* (pp. 109-130). New York, NY: Routledge.

Shellenberger, M., & Nordhaus, T. (2005, January 14). *The death of environmentalism: Global warming politics in a post-environmental world*. Retrieved from http://grist.org/article/doe-reprint/

Spalter, A. M., & van Dam, A. (2009). Digital visual literacy. *Theory Into Practice*, *47*, 93-101.

Sun, Y., Wang, N., & Peng, Z. (2011). Working for one penny: Understanding why people would like to participate in online tasks with low payment. *Computers in Human Behavior*, *27*, 1033-1041.

Tait, A. R., Voepel-Lewis, T., Brennan-Martinez, C., McGonegal, M., & Levine, R. (2012). Using animated computer-generated text and graphics to depict the risks and benefits of medical treatment. *American Journal of Medicine*, *125*, 1103-1110.

TerraChoice. (2011). *The sins of greenwashing home and family edition, 2010: A report on environmental claims made in the North American consumer market*. Retrieved from http://sinsofgreenwashing.org/index35c6.pdf

Thomas, L., Ratcliffe, M., Woodbury, J., & Jarman, E. (2002). Learning styles and performance in the introductory programming sequence. *ACM SIGCSE Bulletin*, *34*, 33-37.

Thorson, E., Wicks, R., & Leshner, G. (2012). Experimental methodology in journalism and mass communication research. *Journalism & Mass Communication Quarterly*, *89*, 112-124.

Treise, D., Walsh-Childers, K., Weigold, M. F., & Friedman, M. (2003). Cultivating the science internet audience impact of brand and domain on source credibility for science information. *Science Communication*, *24*, 309-332.

Trumbo, J. (1999). Visual literacy and science communication. *Science Communication*, *20*, 409-425.

Trumbo, J. (2000). Seeing science: Research opportunities in the visual communication of science. *Science Communication*, *21*, 379-391.

Unnava, H. R., & Burnkrant, R. E. (1991). An imagery-processing view of the role of pictures in print advertisements. *Journal of Market Research*, *28*, 226-231.

Visual.ly. (2013). *Rise of the infographic*. Retrieved from http://visual.ly/rise-infographic

Yu, B., Willis, M., Sun, P., & Wang, J. (2012). Crowdsourcing participatory evaluation of medical pictograms using Amazon Mechanical Turk. *Journal of Medical Internet Research*, *15*, e108-e108.

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